MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022 / 2023 SESSION (TERM ID 2220)

DAD 5111 – FUNDAMENTALS OF ALGORITHM DESIGN

(EAI)

6 JULY 2023
9.00 a.m. – 11.00 a.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 9 pages.
2. There are **TWO (2)** sections:
   - Section A: Multiple Choice Questions (10 Marks)
   - Section B: Structured Questions (30 Marks)
3. Answer **ALL** questions.
4. Please write your answers in the **Answer Booklet** provided.

SECTION A: MULTIPLE CHOICE QUESTIONS (10 MARKS)

Instructions: Choose the correct answer. Write your answer on the provided Answer Booklet.

1. Which of the following time complexity represents the fastest growing rate as the input size increase?

   A. O(1)
   B. O(log n)
   C. O(n)
   D. O(n log n)

2. What is the asymptotic running time of the following algorithm as a function of n?

```
for i←1 to n do
   for j ←1 to n do
       print "Hello"
```

   A. O(n)
   B. $O(n^2)$
   C. O (n log n)
   D. O (log n)

3. Which of the following best describes the concept of "recursion"?

   A. A technique where a function calls itself to solve a problem by breaking it down into smaller similar subproblems.
   B. A loop construct used for repeating a block of code a specific number of times.
   C. A data structure used for organizing and accessing elements in a specific order.
   D. All of the above.

4. A (n) _____ is typically used to implement the queue in the Breadth First Search (BFS) algorithm, which is used to track the vertices to be explored.

   A. stack
   B. linked list
   C. heap
   D. array

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5. Apply Kruskal algorithm on the graph given in Figure A1. Which of the following path will be rejected to produce MST if the starting vertex is *A*?

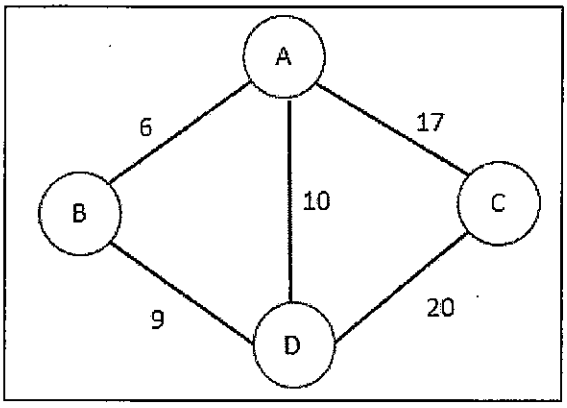

Figure A1: Undirected graph

I. *A-C*
II. *A-D*
III. *B-D*
IV. *C-D*

A. I and IV
B. I and II
C. II and IV
D. III only.

Continued...

6. Table 1 shows the DP tabulation of solving the matrix chain multiplication problem. What is the minimum number of multiplications of the matrices?

	1	2	3	4	
p0 -5	0	120	88	158	1
p1-4	0	48	104		2
p2-6	0	84			3
p3 -2	0				4
p4 -7					

Table 1: DP tabulation of matrix chain multiplication

A. 84
B. 88
C. 104
D. 158

7. A(n) _____ is a subset of the graph's edges that connects all vertices with the minimum total weight without any cycles.

A. undirected graph
B. minimum spanning tree (MST)
C. forest
D. acyclic graph

Continued...

Question 8 and 9 are based on Table 2.

8. Table 2 shows the DP table of solving a 01 Knapsack problem. What is/are the selected item(s)?

			0	1	2	3	4	5	6	7
wt	*b/v*	0	0	0	0	0	0	0	0	0
4	*15*	1	0	0	0	0	15	15	15	15
3	*6*	2	0	0	0	6	15	15	15	21
5	*18*	3	0	0	0	6	15	18	18	21
6	*22*	4	0	0	0	6	15	18	22	22

Table 2: DP table of optimal benefits

A. Item 1 and 2
B. Item 1 and 3
C. Item 3
D. Item 4

9. What is the maximum capacity of the knapsack?

A. 7 kg
B. 6 kg
C. 18 kg
D. 22 kg

10. The _____ in the Ford-Fulkerson algorithm represents the remaining capacity of the edges in the network after finding augmenting paths during each iteration of the algorithm.

A. residual graph
B. array
C. min-cut
D. augmented path

Continued...

SECTION B: STRUCTURED QUESTIONS (30 MARKS)

Instructions: Answer ALL questions. Each question carries 10 marks.

QUESTION 1 (10 MARKS)

a) Apply the DFS-based algorithm to solve the *topological sorting* problem for the following diagraph shown in Figure B1. Use vertex **H** as the starting point. Visit vertices in alphabetical order.

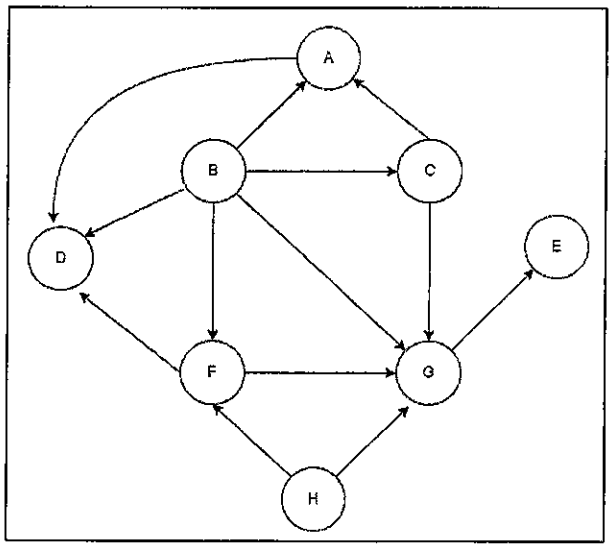

Figure B1: Directed graph

i. Show your working with use of stack and an array to store the topological ordering. (3 marks)

ii. Redraw the spanning tree with the back-edges. (1.5 marks)

iii. Redraw the graph in linear ordering. (1.5 marks)

b) Perform Quick Sort algorithm on the following array. Use the last element as the pivot. Label your diagram with the method accordingly. (4 marks)

33	15	8	13	4

[TOTAL 10 MARKS]

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QUESTION 2 (10 MARKS)

a) Based on the Fractional Knapsack algorithm as shown in Figure B2, answer the following questions:

```
Algorithm fractionalKnapsack(S, W)
  Input: set S of n items with benefit b_i and weight w_i;
         max. weight W
  Output: amount x_i of each item i to maximize benefit with
          weight at most W
  for each item i in S
      x_i ← 0
      v_i ← b_i / w_i        {value}
  w ← 0                      {current total weight}
  while w < W
      remove item i with highest v_i
      x_i ← min{w_i , W - w}
      w ← w + x_i
```

Figure B2: Fractional Knapsack algorithm

You are given a 'knapsack' that can carry maximum weight 5 kg. There are four items with the following weights and benefits as shown in Table 3.

Item:	A	B	C	D
Weight (kg):	2	1	3	2
Benefit ($):	12	10	20	15

Table 3: List of items and its available weight and benefit.

i. Solve this problem with greedy technique to find the optimal benefit of the items you can carry using the knapsack. Show your working steps (4 marks)

ii. List out the item(s) that you can carry, the weights and optimal benefit, based on your answer in (i). (1 mark)

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b) Refer to the following *st*-flow network as shown in Figure B3.

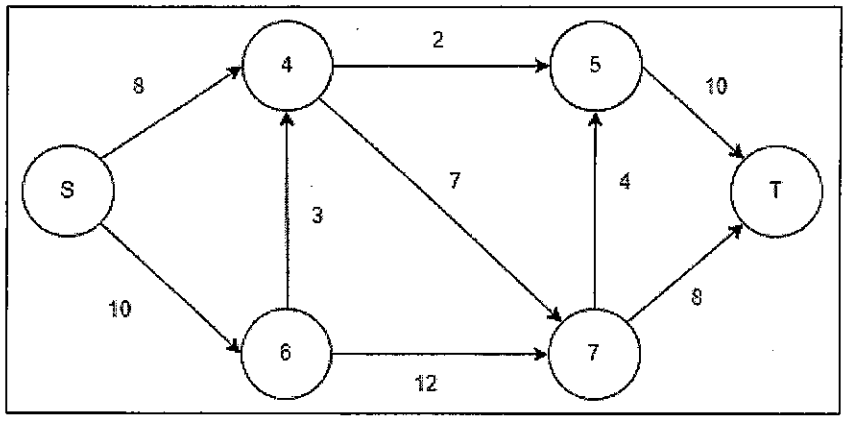

Figure B3: st-Flow Network

i. Apply the Ford-Fulkerson algorithm to determine the maximum flow from ***S*** to ***T***. List the augmenting path that you use to get the maximum flow. (4.5 marks)

ii. Show or list the minimum cut in the network. (0.5 marks)

[TOTAL 10 MARKS]

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QUESTION 3 (10 MARKS)

a) Based on the graph shown in Figure B4, step through Dijkstra's algorithm to calculate the shortest paths from node ***E*** to all other nodes on the graph.

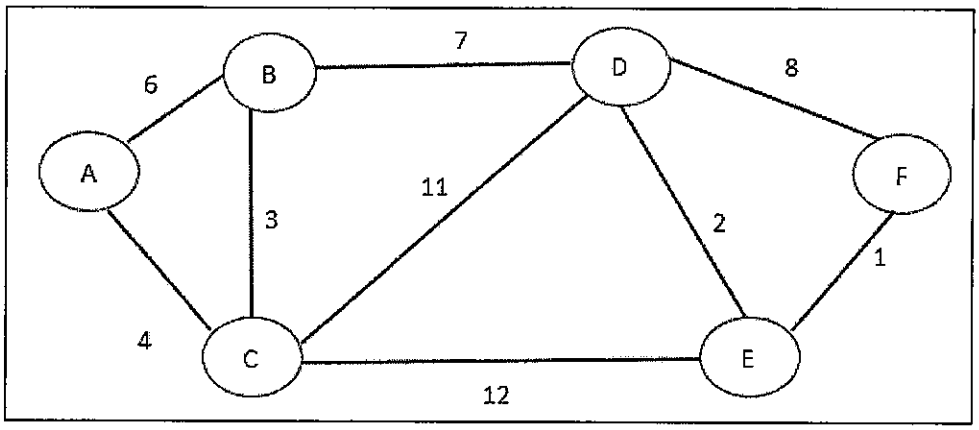

Figure B4: Undirected graph

i. Show your steps as in the table below. Cross out old values and write in new ones, from left to right within each cell, as the algorithm proceeds. (3.5 marks)

Vertex	Shortest distance from E	From
A		
B		
C		
D		
E		
F		

ii. List the vertices in the order in which you marked them visited.(0.5 marks)

iii. Indicate the lowest-cost path from node ***E*** to node ***C***. (0.5 marks)

iv. Indicate the lowest-cost path from node ***E*** to node ***A***. (0.5 marks)

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b) Apply Prim's algorithm to the following graph as shown in Figure B5 to find a minimum spanning tree (*MST*). Start from vertex ***G***.

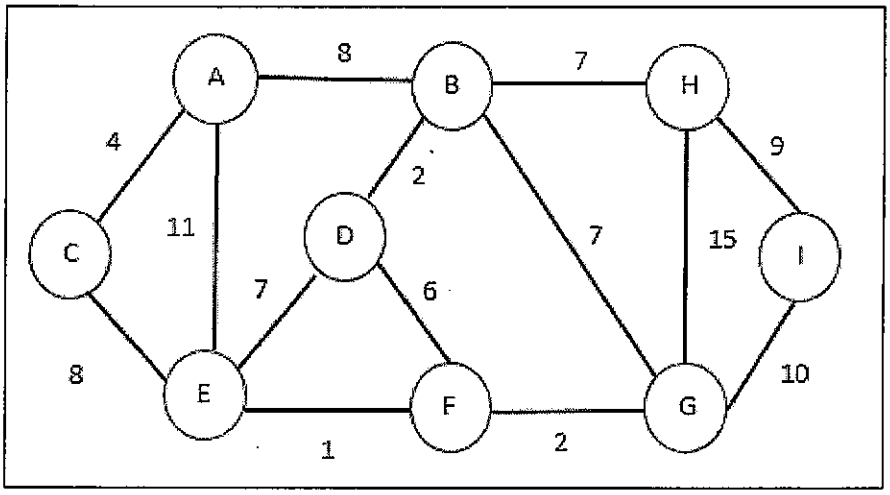

Figure B5: Undirected graph

i. State the order of the edges to the tree to obtain an MST. (2 marks)
ii. What is the total weight of the MST? (1 mark)
iii. Draw the MST obtained. (2 marks)

[TOTAL 10 MARKS]

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